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The author discusses the current basis of the DoD?s management and oversight of MDAPs (i.e., their dollar value) and proposes a new paradigm in which the level of management and oversight would be based on the level of risk an MDAP represents. The author also examines the extent to which the DoD is prepared to assess the following categories of risk: technical, system integration, design, production, and business. Finally the author makes recommendations to improve the DoD?s ability to assess these risks.

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Risk Factors versus Dollar Value: Changing How Weapon System Programs are Managed

Robert Murphy—Robert Murphy retired as a member of the Senior Executive Service after a 33-year career in the US Navy's Nuclear Propulsion Program. He finished his career as the Program's Director of Resource Management, responsible for budget, acquisition and logistic support. While on active Government service, he participated in the acquisition of every nuclear submarine in the US fleet today, in addition to design contracts for SEAWOLF and VIRGINIA Class submarines. Since retiring from public service, he has been consulting for both commercial and government organizations, specializing in major system acquisitions. Such projects have included several cost studies of VIRGINIA Class submarines, in addition to advising on the most recent multi-year contract for acquisition of these submarines. RAND research projects have included several studies of the United Kingdom nuclear submarine industrial base. Murphy earned an MBA from George Washington University.

Abstract

The author discusses the current basis of the DoD's management and oversight of MDAPs (i.e., their dollar value) and proposes a new paradigm in which the level of management and oversight would be based on the level of risk an MDAP represents. The author also examines the extent to which the DoD is prepared to assess the following categories of risk: technical, system integration, design, production, and business. Finally, the author makes recommendations to improve the DoD's ability to assess these risks.

Preface

Today's defense environment is placing growing pressure on defense policymakers to be nimble and adaptive, particularly with respect to acquisition systems and processes. This occasional paper is one in a series drawing upon the expertise of core RAND Corporation staff to explore issues and offer suggestions on topics that are likely to be of critical importance to the new leadership: the use of competition, development of novel systems, prototyping, risk management, organizational and management issues, and the acquisition workforce. The papers are designed to inform new initiatives for markedly improving the cost, timeliness, and innovativeness of weapon systems that the Department of Defense (DoD) intends to acquire.

The Office of the Secretary of Defense (OSD) requires review of Major Defense Acquisition Programs and decisions by senior officials on the basis of a program's dollar value, irrespective of risk. In this paper, we propose a new paradigm in which the level of management and oversight would be based on the level of risk a program represents, including technical, system integration, design, production, and business innovation risk. We also examine the extent to which the DoD is prepared to assess these categories of risk and identify descriptive levels that could be used to assess and categorize design and business process risk.

This study was sponsored by the Office of the Under Secretary of Defense for Acquisition, Technology, and Logistics (OUSD(AT&L)) and conducted within the Acquisition and Technology Policy Center of the RAND National Defense Research Institute, a federally funded research and development center sponsored by the Office of the Secretary of

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Introduction

Currently, acquisition programs are grouped and then managed at the Office of the Secretary of Defense (OSD) by dollar value— depending on the dollar value, the OSD provides different levels of oversight and different management processes. This approach has been constantly refined over the years, without having produced any noticeable improvement in terms of reducing the cost growth, schedule slippage, and performance shortfalls that continue to plague the acquisition of weapon system programs. This paper argues for a different paradigm: The level of overall risk inherent in a program should be the main basis for determining the process and level of review a project should receive.[1]

Drawing upon examples from warship acquisition programs, this paper also argues that inadequate assessment and management of various discrete program risks results in adverse cost, schedule, and performance outcomes. We examine existing scales for assessing some of these discrete program risks and make recommendations to better assess and manage several programs within the Defense Acquisition Management System.

Managing by Risk Level versus Dollar Value

Currently, the OSD requires review of acquisition programs and decisions by senior officials on the basis of a program's dollar value, irrespective of risk, as shown in Table 1.

However, some very costly projects might have significantly less risk than projects of similar cost, and thus should require less oversight as well as the use of different criteria at milestone reviews.[2] Conversely, projects may cost little but have a lot of risk because they tend to push the state of the art in technology and may also involve novel business or design processes that may require more comprehensive oversight than just dollar value would otherwise indicate. An excellent example of this type of program—the Advanced SEAL Delivery System (ASDS)—was discussed in a May 2007 report by the US Government Accountability Office (GAO). The ASDS is a Special Operations Forces' battery-powered submersible, carried to a deployment area by a submarine. The operating parameters for the submersible required development of batteries that would push the state of the art in that technology. The initial design, construct, and deliver contract was awarded

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[1] Cost is a factor that must be considered when determining the level of review. A multibillion dollar program requires high-level review because even a small amount of cost growth involves large dollar amounts.

[2] For example, the Navy is about to restart construction of two DDG 51-class destroyers at a cost in excess of several billion dollars. Over 60 destroyers of this class have already been delivered or are in the final stages of construction. Because of this track record, restarting construction of two new DDG 51s will no doubt expose the Navy to a far less risk of adverse cost, schedule, and performance outcomes than construction of three multibillion DDG 1000-class ships, which are now being designed and just entering construction.

for $70 million in 1994 for delivery in 1997; because of the dollar value, Milestone Decision Authority (MDA) resided with the Navy, which ultimately accepted delivery of ASDS in 2003 in “as is” condition at a cost in excess of $340 million. The GAO concluded that “Had the original business case for ASDS been properly assessed as an under-resourced, concurrent technology, design, and construction effort led by an inexperienced contractor, DoD might have adopted an alternative solution or strategy” (GAO, 2007, p. 13).

Table 1. Basis and Level of Program Oversight
(USD(AT&L), 2008)

Program Acquisition Category (ACAT)	Basis for ACAT Designation Milestone Decision Authority (MDA)	Milestone Decision Authority (MDA)
I	Estimated total expenditure for research, development, test, and evaluation (RDT&E) of more than $365 million or for procurement of more than $2.190 billion	ACAT ID: Under Secretary of Defense for Acquisitions, Technology, and Logistics ACAT IC: Head of DoD Component (e.g., Secretary of the Navy) or, if delegated, DoD component acquisition executive (e.g., Assistant Secretary of the Navy for Research, Development, and Acquisition)
II	Estimated total expenditure for RDT&E of more than $140 million or for procurement of more than $660 million	DoD component acquisition executive or designate (e.g., program executive officer)
III	Does not meet criteria for ACAT II or above; less than an MAIS program ACAT ID: Under Secretary of Defense for Acquisition, Technology, and Logistics	Designated by DoD component acquisition executive at the lowest level appropriate (e.g., program manager)

NOTE: Estimated expenditures are in FY 2000 constant dollars.

Focusing on Causes Rather than Consequences

Risk, or the exposure to the chance of failure, is a word heard frequently in the acquisition community. All acquisition programs face risk of some form or another. Arguably, any new major weapon system that could be developed, produced, and fielded with no risk involved is probably not worth acquiring.

Overtly or otherwise, much of a program manager’s time is spent managing risk. After all, the Defense Acquisition Management System, shown in Figure 1, is, in essence, a risk-management process designed to ensure success in the timely delivery of weapon systems that meet warfighter requirements while staying within budget.

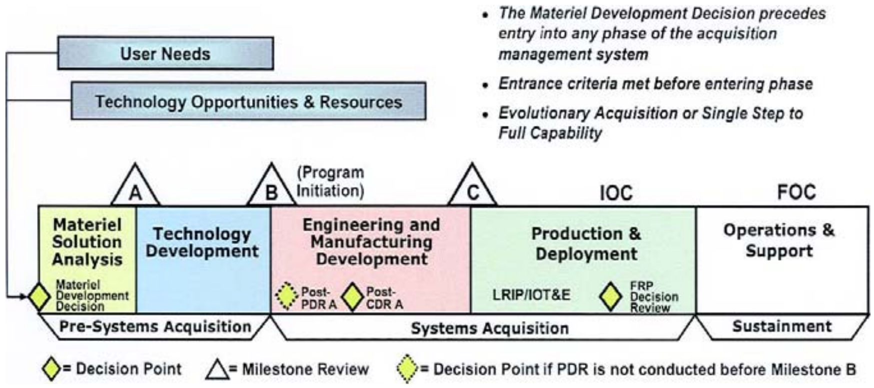

Figure 1. The Defense Acquisition Management System
(USD(AT&L), 2008)

The risks most frequently mentioned by defense acquisition officials are cost growth, schedule slippage, and performance shortfalls. This is not surprising as cost, schedule, and performance are the primary attributes by which programs are assessed for success or failure. Moreover, the Defense Acquisition University (n.d., p. 2) teaches that cost, or performance schedule, and performance are the risk factors that program managers must assess and manage "to ensure that DoD is acquiring optimum systems that meet all capability needs."

Assessment of cost, schedule, and performance is clearly a management task, and a good program manager assesses these risks using periodic data accumulated into management reports to identify problems, regain lost ground, and then stay on track. However, these are broad measures of risk. A better program manager proactively manages by using discrete program risks and submeasures that allow him or her to look ahead and act to avoid adverse cost, schedule, and/or performance trends and outcomes. In other words, managing by cost, schedule, and performance measures is akin to driving a car while looking solely in the rearview mirror—it is possible, but only if the road stays straight. A better driver looks mostly out the windshield, with only an occasional look in the mirror; this driver anticipates and easily handles curves in the road.

In this paper, we focus on five discrete programmatic risk categories:

- technical,
- system integration,
- design,
- production, and
- business.

Taken together, these risk categories portray overall acquisition program risk.[3] They interact in numerous ways to affect a project's cost, schedule, and/or performance outcomes: Obviously, technologies that do not work affect performance, but so can poor business decisions that increase cost and lead to features being deleted from the weapon system to remain within budget.

[3] For simplicity, risks involved in fielding, operating, and maintaining the weapon system are not addressed in this paper.

The Defense Acquisition Management System appears to adequately recognize that incorporation of new technologies into a weapon system presents risk, providing metrics to systematically assess this type of risk. Time is also provided in the acquisition process for system integration matters to be identified and resolved, although there is room for improvement. However, as will be discussed in subsequent examples, new approaches in design, production, and business areas of acquisition programs do not appear to receive the same skepticism and comprehensive oversight that new technologies and systems receive.

Well-Defined Process for Assessing Technical Risk Is in Place

"Technical risk" is exposure to the chance that development of critical technologies will not meet program objectives within cost and schedule constraints. In assessing technical risk, program managers must address the uncertainty in their estimates about how much time and effort it will take to make new technologies work. The importance of technical risk is well understood in the acquisition community. For example, DoD guidance states that "the management and mitigation of technology risk…is a crucial part of overall program management and is especially relevant to meeting cost and schedule goals" (USD(AT&L), 2008, para. 3.7.2.2).

Technical risk is also extensively addressed in the Defense Acquisition Management System. The system recognizes evolutionary acquisition as the preferred DoD strategy for rapid acquisition of mature technology for the user. One purpose of evolutionary acquisition (i.e., delivering capability in increments through spiral or incremental development) is to provide time to better manage technology risk and avoid adverse cost and schedule outcomes that often result from trying to achieve difficult requirements in one step.

The DoD has also established a well-defined process based on Technology Readiness Levels (TRLs) to categorize technical risk and help ensure that key decision-makers understand the risk of incorporating different technologies into weapon system acquisition programs (the TRLs are described in Table 2). Using this process, program offices conduct a technology readiness assessment under the auspices of the DoD Component Science and Technology (S&T) Executive; the Deputy Under Secretary of Defense (S&T) evaluates the technology readiness assessment and forwards findings to the Overarching Integrated Product Team leader and Defense Acquisition Board.

The TRLs are a good proxy measurement for technical risk: The lower the readiness level, the more development needed to incorporate the technology into a weapon system; and the more development needed, the greater the risk. Overall, technology risk has been handled fairly well in warship acquisition programs, which tend not to push the state of the art in technology as far as do weapons and sensors. A recent example is the USS Virginia, which incorporates various new technologies[4] and was still delivered within four months of the original schedule established a decade earlier (Casey, 2007).

[4] For example, a nonpenetrating photonics mast versus a periscope, a DC electric system, Lightweight Wide Aperture Sonar Arrays, etc.

Table 2. Technology Readiness Levels
(DUSD(S&T), 2005)

Technology Readiness Levels
1. Basic principles observed and reported 1. Technology concept and/or application formulated 2. Analytical and experimental critical function and/or characteristic proof of concept 3. Component and/or breadboard validation in laboratory environment 4. Component and/or breadboard validation in relevant environment 5. System/subsystem model or prototype demonstration in a relevant environment 6. System prototype demonstration in an operational environment 7. Actual system completed and qualified through test and demonstration 8. Actual system proven through successful mission operations

NOTE: See Mankins (1995).

System Integration Risk Is Assessed, But at Later Stages

The acquisition community also assesses system integration risk, but it lacks effective tools to measure and categorize this risk early in a program's life cycle. "System integration risk" is exposure to the chance that new and existing technologies being employed in a weapon system may not work together and/or interact with operators and maintainers to meet program objectives within cost and schedule constraints. System integration can be an issue within an individual acquisition program (e.g., when subsystems fail to interact). It can also be an issue between acquisition programs: Many programs develop capabilities that are a component of a larger warfighting capability; individually, the component programs might appear to be a low or moderate risk, but in combination with other programs, the overall risk might be much higher due to coordination and integration issues. A classic example occurred during the Grenada invasion when Army and Navy communications systems did not interact well during the joint operation.

System integration risk is extensively treated after Milestone B, during the engineering and manufacturing development (EMD) phase, at which time a program should demonstrate system integration, interoperability, safety, and utility (USD(AT&L), 2008, para. 3.7.1.1). While appropriate attention is given to system integration risk during this phase, this assessment occurs after the second of three milestones in the process, when programs have typically built up so much momentum that they are difficult to stop, regardless of performance or progress. Early consideration of system integration risk—at Milestone A—by senior decision-makers could result in developing and funding integration-risk mitigation plans that could considerably improve acquisition outcomes.

Combat systems in warships provide an example of the problems that arise when decisions are made without adequate consideration of system integration risk.[5] For example, early decisions on systems architecture and processing approaches made without adequate consideration of risk led to cost, schedule, and performance problems with submarine combat systems for the SSN 688I, SEAWOLF, and Australian Collins-class submarines. According to a report for the Parliament of Australia discussing the Collins-class submarine,

> Of the early decisions in the Collins program, the one which was to have the most public effect was that concerning the nature of the vessels' Combat Data System (CDS). It has been the subsequent failure of this system to meet its design requirements that has left the submarines with a severely impaired combat capability.
>
> By the end of 1982…[the Royal Australian Navy (RAN)] had decided that the electronic combat systems of the new boats would be fully integrated. Instead of the then standard central computer performing all data analysis, the new submarine CDS would use a data bus to distribute information to a number of smaller computer work stations. (Woolner, 2001)

The report then goes on to discuss the lack of appreciation for the risk of switching to the new integrated architecture for combat systems.

> The RAN was not alone in its "grand folly."… The Australian information technology (IT) industry assured the RAN of both the feasibility and inherent advantages of a fully integrated combat system and of its ability to contribute to such a program.
>
> Moreover, the RAN was not the only navy to think that the future of combat data processing lay with fully integrated systems. The USN [U.S. Navy] specified the same concept for its [BSY-2] Integrated Combat System for the U.S. Navy's Seawolf class nuclear attack submarines. This was an even more costly failure than the Collins CDS, absorbing…$1.5 billion [in U.S. dollars] before it was cancelled.[6]

Tools for assessing system-integration maturity earlier on have been proposed. For example, Sauser, Ramirez-Marquez, Magnaye, and Tan (2008) have proposed a System Readiness Level (SRL) index that would incorporate the current TRL scale as well as an Integration Readiness Level (IRL) scale. The IRL scale they describe would use nine levels, which appear compatible with the widely used TRLs and appear to be a good proxy measurement of system integration risk. The proposed IRLs are listed in Table 3.

The Risks of Design Process Management Are Not Well Understood

"Design risk" is exposure to the chance that the weapon system's design will not result in effective operation or be easy to produce. It is axiomatic that a good design is essential to a weapon system's performance, but the impact of design on a weapon system's production cost and schedule outcome is not as well appreciated. However, decisions made early in the design process quickly establish not only the performance but also the ease of manufacture and resultant cost of the weapon system. While the ability of the

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[5] A combat system integrates information from sensors, synthesizes this information for combat commanders, and provides fire control solutions and guidance to weapons.

[6] The original citation mistakenly attributed this to the BSY-1 program.

design to operate effectively can be considered a subset of technical risk, a more holistic approach is for a program manager to assess the chance that the design process to be employed for the weapon system will generate an effective, easy-to-produce weapon.

Table 3. Integration Readiness Levels
(Sauser et al., 2008)

Integration Readiness Levels
2. An interface between technologies is identified with sufficient detail to allow characterization of the relationship.
1. There is some level of specificity to characterize the interaction (i.e., ability to influence) between technologies through their interface.
2. There is compatibility (i.e., a common language) between technologies to orderly and efficiently integrate and interact.
3. There is sufficient detail in the quality and assurance of the integration between technologies.
4. There is sufficient control between technologies necessary to establish, manage, and terminate the integration.
5. The integrating technologies can accept, translate, and structure information for their intended application.
6. The integration of technologies is verified and validated with sufficient detail to be actionable.
7. Actual integration is completed and mission qualified through test and demonstration in the system environment.
8. Integration is mission proven through successful mission operations.

The design process necessary for an effective and producible weapon system involves complex interactions between designers, suppliers, production experts, planners, and estimators. Design process complexity has also increased with the availability of more sophisticated design tools such as electronic product models and computational techniques (e.g., finite element analysis).

Outcomes from two current acquisition programs—the United Kingdom's ASTUTE-class submarine and the US Navy's LPD 17-class of amphibious transport dock ships—demonstrate why senior decision-makers in the OSD acquisition process need to better understand the risks new design processes and tools present. The ASTUTE was the first UK submarine to be designed through use of an electronic, three-dimensional computer product model. The prime contractor's inability to manage this new process resulted in extensive delays when design products needed to build the ship were late. General Dynamics ultimately had to be hired to augment and manage the final stages of the submarine's detail design process. Because of design and other problems, the ASTUTE program has overrun cost greatly and is years behind schedule.

With LPD 17, the US Navy competed the design and production of the first three ships of the class using as major evaluation and award criteria (1) the plans for accomplishing detail design and other functions, (2) Integrated Product Data Environment

(IPDE) tools, and (3) life-cycle cost projections; these criteria were given more weight than price (Comptroller General of the United States, 1997). The then-Avondale Shipyard in New Orleans, Louisiana, partnered with a firm that was developing a new ship design IPDE tool and won the competition. Subsequently, the LPD 17 experienced considerable cost growth (about 70%) and schedule delays (CRS, 2008, p. 12). The GAO attributed much of this cost growth to the new design tool:

> In the LPD 17 program, the Navy's reliance on an immature design tool led to problems that affected all aspects of the lead ship's design. Without a stable design, work was often delayed from early in the building cycle to later, during integration of the hull. Shipbuilders stated that doing the work at this stage could cost up to five times the original cost. The lead ship in the LPD class was delivered to the warfighter incomplete and with numerous mechanical failures. (GAO, 2007)

Senior decision-makers should require a program manager proposing to use new design processes, tools, or organizations to design a weapon system to justify selection of the new process, tool, or organization and develop an appropriate risk mitigation plan. An example of a design process mitigation plan comes from the VIRGINIA-class submarine program. Prior to VIRGINIA-class construction using a new Integrated Product and Process Development (IPPD) approach, Electric Boat stated,

> a representative section of the ship about a year early with a portion of that section started about two years early. This early, controlled, closely monitored ship construction effort ensured thorough preparation for full-ship application and high confidence in the new process. (General Dynamics Electric Boat, 2002, p. 33)

Evaluation of Production Risks Lacks Rigor

An earlier and more rigorous evaluation of production risks could save the DoD much difficulty and taxpayers a lot of money. "Production risk" is exposure to the chance that the facility, labor, manufacturing processes, and procedures will fail to produce the weapon system within time and cost constraints. Producibility—or "production capability"—is a function of the design; production facilities; management skills, processes, and experience; and workforce skills and experience. The DoD requires assessment of contractors' production capability before production contract award in the production and deployment phase, but this may be too late because, at this point, production may be locked in by the organization that won the design contract. Moreover, in the authors' experience, and as exemplified in the LPD 17 source-selection criteria discussed earlier, the production category of risk does not receive the same emphasis in selecting a shipbuilder as other factors, such as design concepts, past performance, and estimated cost.

The Navy's DD 963-class of destroyers and LHA 1-class of amphibious assault ships are classic examples of programs in which the DoD considered design and production risk acceptable when awarding contracts, but which went on to experience about the worst of every production factor possible. These ships presented little technical and system integration risk, but ended up far behind schedule and over cost, due in part to identifiable production risks. Contracts were awarded to the lowest bidder, Litton Industries, which owned the Ingalls shipyard in Pascagoula, Mississippi. In the late 1960s, Litton Industries decided to invest in an expansion of design and production facilities for warships, building a new shipyard on the west bank of the Pascagoula River, across from its existing shipyard. The new shipyard was designed to be operated with a new production control system using modular techniques for building ships (Northrup Grumman, 2008).

After the award of the LHA- and DD 963-class contracts to Ingalls for nine LHAs and 30 DD 963s in the late 1960s, Ingalls' management decided to shift construction of some commercial container ships from the old, conventional yard to the new facility (Northrup Grumman, 2008). The expectation was that doing so would allow the new facility to start up and have any problems worked out while the LHA and DD 963 were being designed. However, production of the container ships using the new control system led to delays; consequently, the ships were occupying facilities and using manpower needed to start production of the LHAs and DD 963s. Production of the LHAs and DD 963s fell far behind and, in combination with other problems (design-related issues, inflation, etc.), the costs were overrun substantially and the ships were late (GlobalSecurity.org, 2008).

A greater emphasis on evaluating production risks could have saved an enormous amount of time and money, but the promised cost savings resulting from construction in a new, state-of-the-art ship fabrication and assembly facility proved too good to be true. The assessment that the facility would be derisked by building container ships first turned out to be wrong, and, meanwhile, two entire classes of ships had been priced and placed under contract.

A promising approach, initiated by the Missile Defense Agency, may provide program offices across the DoD with better insight about production risk. The agency extended the notion of TRLs to engineering and manufacturing by developing Engineering and Manufacturing Readiness Levels (EMRLs) to assess the maturity of a program's design, related materials, tooling, test equipment, manufacturing, quality, and reliability levels. There are five EMRLs, as shown in Table 4.

Table 4. Engineering and Manufacturing Readiness Levels
(DUSD(S&T), 2005)

Engineering and Manufacturing Readiness Levels
3. System, component, or item validation in laboratory environment or initial relevant engineering application or breadboard, brass-board development.
1. System or components in prototype demonstration beyond breadboard, brass-board development.
2. System, component, or item in advanced development. Ready for low-rate initial production.
3. Similar system, component, or item previously produced or in production. System, component, or item in low-rate initial production. Ready for full-rate production.
4. Identical system, component, or item previously produced or in production. System, component, or item in full-rate production.

The Risk of Early Business Decisions Is Not Fully Appreciated

Business decisions made early in a program's life can significantly affect cost, schedule, and performance outcomes. "Business risk" is exposure to the chance that the overall acquisition strategy for a program will not result in the desired cost, schedule, and/or performance outcomes. Decisions about the process to select who will build the weapon system, the standards to which it will be built, and the schedules for designing and building it

all entail risk that is not always appreciated up front. To evaluate business risk, program managers should assess the following: (1) the extent to which the acquisition strategy can result in selection of the most effective, efficient design and most effective, efficient production entities; (2) whether cost estimates and schedules are valid; (3) whether proper government oversight organizations are in place; and (4) whether project personnel with proper training and experience are available.

A good example of early business decisions gone bad is the Navy's Littoral Combat Ship (LCS) Program. The lead ship, USS Freedom (LCS 1), was recently delivered after experiencing substantial cost overruns and delivery delays. In congressional testimony given to explain these outcomes, the US Navy (2007) identified the following tenets of the new business model used to acquire the LCS:

- Construction of LCS seaframes in midtier shipyards that "perform predominately commercial work, maintaining business processes and overhead structures that keep them competitive in the world market" (i.e., little warship experience).[7]
- "A rapid 24-month build cycle for each seaframe, as opposed to the five or more years that have become the norm in naval shipbuilding."
- "The LM lead ship detail design and construction effort was initiated simultaneously and the lead ship commenced construction only seven months after the start of final design (i.e., concurrent design/build)."
- "In order to address the challenges of technical authority under this environment (reduction in NAVSEA technical personnel), in February 2003, NAVSEA and PEO Ships made two joint decisions. The first was to work with the American Bureau of Shipping (ABS) to develop a set of standards (Naval Vessel Rules) that could be applied to non-nuclear naval combatant ships. The second was to utilize ABS to class[8] both LCS and DDG 1000 using the new rules."

No doubt there were good arguments for these individual program tenets. However, the cumulative effect of the risks involved in building a new design warship in small commercial shipyards with little warship experience during a rapid, concurrent design/build process and to a set of technical standards themselves under development appears to have been greatly underappreciated. In that same congressional testimony, the Navy identified cost drivers for LCS 1 as "concurrent design-and-build while incorporating Naval Vessel Rules (NVR), reduction gear delays created by a manufacturing error, and insufficient program oversight" (US Navy, 2007). The risks inherent in utilizing an entirely new business model to acquire warships were obviously neither adequately assessed nor managed.

One way to avoid such risk would be to require program managers proposing new and/or radical business models to fully justify why the new model is superior to past practice, recommend more frequent assessment points than now required by the Defense Acquisition Management System, and incorporate exit strategies in contracts for the government to use if the program fails to meet expectations.

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[7] To better understand the differences between military and commercial shipbuilding, see Birkler et al. (2005).

[8] The American Bureau of Ships is known in the commercial shipping industry as a "classification society," which is an organization that sets standards for design and construction of vessels and integral machinery within.

Conclusions

The Defense Acquisition System Framework has sufficient tools and allows time for proper assessment and management of technical risk and, to some extent, of system integration risk. However, design, production, and business risks are not always adequately assessed and managed. As shown in this discussion, scales exist that represent good proxy measurements of technical, systems integration, engineering, and production risks; what is missing are descriptive levels that could be used to assess and categorize design and business process risk. We recommend that the DoD explore establishing such levels and, in Tables 5 and 6, offer starting points for doing so (based on the authors' experience), which may help program managers more carefully consider these risks.

In addition, we recommend the following actions to better assess and manage program risk overall:

- Assess, categorize, and individually review each technical, system, design, production, and business risk of a program at each milestone in the Defense Acquisition Management Framework.
- Require program managers to justify new or radical approaches to design, production, or business processes and develop and implement risk mitigation plans and/or contract off -ramps.

Table 5. Proposed Design Process Levels

Design Processes
1. New, unproven processes. New design tools under development. New design organization.
2. Large expansion of existing design organization. Many new designers and supervisors unfamiliar with design tools and processes.
3. Existing design organization using radically changed design tools, processes, and/or technologies.
4. Experienced design organization using new design tools with proven processes.
5. Experienced design organization using existing, proven design tools and processes.

Table 6. Proposed Business Process Levels

Business Processes	
4.	Using a new, unproven approach to source selection. Encouraging new sources of supply. Acquiring new technologies without well-established cost-estimating relationships. Requiring new government and/or contractor organizations to be formed.

1. Using new procurement process in established industry. Cost-estimating relationships only at high levels. Requires expansion of government and contractor organizations.
2. Evolutionary change from prior acquisition strategies. Good cost-estimating relationships. Existing government and contractor organizations can easily adapt to changes.
3. Using same approach to buying similar products. Well-established cost-estimating relationships exist. Experienced government and contractor organizations involved.
4. Acquiring more of what has been successfully bought before. Using the same contractor and government organizations.

Although such tools would enhance the ability of program offices to assess and manage risk, the DoD should also consider changes in oversight. As stated at the outset of this paper, the current acquisition system requires review and decisions by senior officials on the basis of a program's dollar value, irrespective of risk. A better use of their limited time may be to focus on programs with high risks, letting less-senior officials deal with lower-risk programs, regardless of dollar value. For example, the DoD could

- lower the MDA level for future milestones down
  - —two levels for programs with low risk in all risk categories9
  - —one level for programs with moderate risk in all risk categories.10
- continue to follow the patterns for decision authority as established in the Defense Acquisition Management System for any program with greater than moderate risk in any of the five categories of program risk.

In this way, senior decision-makers might be able to better concentrate their limited time on the real potential problem areas in a program before problems occur, and direct actions to be taken to avoid and/or mitigate potential problems.

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[9] Determination of what constitutes "low risk" is obviously subjective. For our purposes, "low risk" would be technology and integration levels 8 and 9 and EMRL, design, and business levels 4 and 5.

[10] For our purposes, "moderate risk" would be TRL and IRL 5 and 6 and EMRL design and business levels 3.

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Outline

- Current risk focus in DOD acquisition
- Discrete programmatic risk categories
  - Technical
  - System integration
  - Design
  - Production
  - Business
- Conclusions and recommendations

Current risk focus in DOD acquisition

- Manage by dollar value
  - Program acquisition categories stratified by $
  - The higher the $, the higher the decision authority
  - Some low $ value programs could benefit from higher level scrutiny (e.g. ASDS)
  - Some high $ value programs are low risk (e.g. DDG 51 Class restart)
- Causes versus consequences
  - Are cost, schedule and performance risks that can be managed or consequences of discrete risks?

Discrete programmatic risk categories

- Technical
  - Well understood in acquisition community
  - Technology Readiness Levels
    - Good proxy measure for technical risk
    - Well defined process for technology readiness assessment
  - Technical risk handled well in ship acquisition programs (e.g. VIRGINIA Class)

Discrete programmatic risk categories

- System Integration
  - Was a big problem with submarine combat systems (e.g. COLLINS, SUBACS, BSY 1 & 2)
  - Extensively treated after MS B, during engineering and manufacturing development (EMD) phase
  - Early assessment could improve outcomes
  - Sauser proposal for Integration Readiness Level scale
    - Nine levels, compatible with TRLs

Discrete programmatic risk categories

- Design
  - Will design process generate an effective, easy-to-produce weapon system?
  - Design process problems can lead to major cost and schedule overruns (e.g. ASTUTE & LPD 17)
  - Decision makers need to better understand the risks new design processes and tools present
  - Program managers should:
    - Justify new processes and tools
    - Develop appropriate risk mitigation plan (e.g. VA early ship section build to prove/debug new processes & tools)

Discrete programmatic risk categories

- Production
  - Production readiness review before production contract award
  - Earlier program decisions may lock program into production contractor, ready or not
  - Expected savings from new production facility for LHA 1 and DD 963 Classes led to problematic contracts
  - MDA's Engineering & Manufacturing Readiness Levels promising tool for early assessment

Discrete programmatic risk categories

- Business
  - LCS represented major changes to Navy ship acquisition model
    - Construction in commercially competitive yards
    - Rapid 24 month build cycle
    - Simultaneous design and construction
    - Use of ABS Naval Vessel Rules
  - Require PMs proposing new &/or radical business models to:
    - Justify new approach
    - Incorporate exit strategies in Acquisition Strategy

Conclusions and recommendations

- Better & earlier attention to discrete causes of risk can lead to better cost, schedule and performance consequences
- Focus oversight on risk level, not $ value
  - Assess each discrete risk at each milestone
  - Require PMs to:
    - Justify new or radical approaches to design, production or business processes
    - Develop risk mitigation plans & exit strategies
  - Lower the Milestone Decision Authority level for programs assessed with low risk